

## DSS 13 Frequency Stability Tests

T. Y. Otoshi and M. M. Franco

Radio Frequency and Microwave Subsystems Section

*In a previous article, the results of frequency stability tests at DSS 13 were presented in table form for  $\tau = 1000$  s for the test period May 1985 through March 1986. This article is a continuation of that initial report and presents specially selected Allan sigma (square root of variance) plots of each of the subsystem test configurations previously reported. An additional result obtained from tests performed during July 1986 has been included in this article for completeness. The Allan sigma plots are useful in that frequency stability information is not only given for  $\tau = 1000$  s, but for  $\tau$  values in the regions of 1 s, 10 s, 100 s, 500 s, and 2000 s as well.*

### I. Introduction

In a previous article [1] the frequency stability test results for the X-band uplink and X-band downlink system of the R&D system at DSS 13 were reported. Figures 1 and 2 show the system that was tested and also the test output ports. The results for  $\tau = 1000$  s were tabulated for various subsystems as well as end-to-end system configurations. The problem of presenting results only for  $\tau = 1000$  s is that erroneous conclusions might be drawn concerning the frequency stability of the system being tested. To ensure that the system is functioning properly, it is necessary to examine the test data at small values of  $\tau$  as well as at the larger values. Therefore, it is the purpose of this article to present Allan sigma plots for the subsystems and end-to-end system test configurations that were previously reported upon. Allan sigma plots give information not only for  $\tau = 1000$  s, but also for  $\tau$  values at 1 s, 10 s, 100 s, 1000 s, and higher (depending on the duration of the test).

The Allan sigma plots were obtained through the use of a computer program written for the Univac 1100 computer by C. Greenhall. An excellent discussion of the Allan Variance theory and the beat frequency measurement technique, as

well as the data reduction equations for this computer program, are given by Greenhall in [2]. A possible departure from Greenhall's terminology used in [2] is the term "Allan sigma," which will be used in this article. To be consistent with Greenhall's definition, the Allan sigma plots might have been called Allan deviation plots. More appropriately, these plots might be referred to as fractional frequency stability plots. In as much as the plots from Greenhall's computer program are labeled "sigma" for Y-axis values, these plots will be referred to as Allan sigma plots for purposes of this article. The terms Allan sigma, Allan deviation, and fractional frequency stability have been used interchangeably in various reports by the authors. It is not the intent to confuse the reader, and we hope terminology for frequency stability measurements will be standardized in the near future.

For the purpose of making this article concise without sacrificing the transfer of knowledge or information, many symbols and abbreviations will be employed throughout in the main text, figures, and tables. These symbols and abbreviations are defined in the Appendix A. It is the intention of the authors to use symbols that are logical and self-defining.

## II. Test Configurations and Test Results

A discussion and description of the instrumentation and test procedures for the different configurations previously tested were given in [1]. Except for the EEOLS configuration test procedure, which was not correctly described in [1], descriptions of test setups and test procedures will be omitted in this article. The current article should be considered as a supplement to the earlier article and thus only the Allan sigma plots for each of the different configurations tested at DSS 13 are presented. The Allan sigma plot presented here for each configuration is intentionally selected to be the best of all of the plots for each configuration. However, with the exceptions of the XLTRX, MMRX, XLTRS, and MMRS test configurations, the selected best plots are nearly representative of the typical result obtained most frequently for the particular test configuration. It should be mentioned that most of the tests were performed during the coolest part of the day or whenever the outside air temperature did not vary greatly. The temperature variations during the tests are shown on the Allan sigma plots. It is not known how much degradation would have occurred had the tests been conducted under less favorable weather conditions.

Figures 3 through 6 are Allan sigma plots for test configurations involving only the X-band uplink frequencies. Figures 7 through 10 are for test configurations involving only DSN X-band uplink and DSN X-band downlink frequencies, and Figs. 11 through 14 are for test configurations involving only X-band uplink and S-band downlink frequencies.

In the following presentation of test results, the nomenclature and symbols defined in Appendix A will be used extensively. The results that one should look for in an Allan sigma plot are (1) the  $\sigma$  value at  $\tau = 1$  s, (2) linearity as a function of  $\tau$  up to about  $\tau = 500$  s, and (3) the value of  $\sigma$  at about  $\tau = 1000$  s. For regions of  $\tau > 3000$  s, the curve may continue in a downward trend or it may begin to rise depending upon long-term drifts [2]. Observe to see that there are no humps or sudden jumps in the curve between 1 s and 500 s. Any humps or jumps in the curve below about  $\tau = 500$  s may indicate subsystem problems.

The value of  $\sigma$  at  $\tau = 1000$  s is of most interest to Radio Science experimenters for the Gravity Wave Detection Experiment [3]. Therefore, for quick reference purposes, the  $\sigma$  values at  $\tau = 1000$  s for each of the test configuration results shown in the Allan sigma plots are tabulated in Tables 1 through 3. Any difference between the tabulated results and the interpolated values obtained from the plots at  $\tau = 1000$  s can be explained by the fact that for the plots, the computed data points do not lie exactly at  $\tau = 1000$  s, while the results

for Tables 1 through 3 were computed exactly at  $\tau = 1000$  s through the use of a separate computer program.

Figures 3 and 4 show Allan sigma plots for tests made on EXCCL configurations using two-mixer and one-mixer methods, respectively. The X-band uplink frequency for test results in Figs. 3 and 4, respectively, were 7166.9 and 7200 MHz. The output test port for both results was port 4 (shown in Fig. 1). Note that the Dana synthesizer,  $\times 16$  multiplier, 36.6 m (1,200 ft) of uncompensated cable, as well 36.6 m of phase-stabilized cable carrying 100 MHz from the control room into the cone are all part of the EXCCL configuration being tested. The two-mixer method was described previously in [1] and is a new method developed to enable tests to be made at test frequencies that are not integer multiples of 100 MHz. The one-mixer method is the more familiar method that is used to make tests when the test frequency is an integer multiple of 100 MHz. This one-mixer method does not require an additional frequency synthesizer and mixer as part of the test setup as does the two-mixer method, but is not as versatile.

Figures 5 and 6 are Allan sigma plots for tests made on the XMTCL and XMTOL configurations, respectively. In addition, XTIME and YFREQ plots are shown. These latter plots are useful for providing a measure of stability versus time. They are also helpful for diagnostic purposes and isolating bad data points. Sometimes the bad points can be related to non-typical station events. The output test port for the XMTCL and XMTOL configurations is port 5 (Fig. 1). Note that this test configuration includes the X-band transmitter as well as the EXCCL test configuration described previously. The X-band uplink frequency for both test configurations was 7200 MHz.

Figure 7 is an Allan sigma plot for tests made on the XLTRX configuration. The test output port for this configuration was port 6 (Fig. 1). Note that the exciter subsystem and the X-band UL to X-band DL frequency translator are parts of the system being tested. In order to minimize excessive use of the X-band transmitter for some types of subsystem testing, the X-band transmitter was intentionally bypassed and not included in the test configuration for this particular test result. The X-band uplink and X-band downlink frequencies for this test were 7162.3 MHz and 8415.0 MHz, respectively.

Figure 8 is an Allan sigma plot for tests made on the MMRX configuration where the output port is port 7 (Fig. 1). The X-band uplink and X-band downlink frequencies for this test were 7162.3 MHz and 8415.0 MHz, respectively. The subsystems included in the test configuration are the exciter subsystem, X-band UL to X-band DL frequency translator,

X-band maser, X-band MMR, and the 36.6 m (1,200 ft) of cable carrying the 315-MHz IF signal back to the control room. The X-band transmitter was not included in the test configuration for this particular test result. The results for the MMRX test were much better than expected.

Figure 9 is an Allan sigma plot for the EECLX configuration where the output test port is the 1-MHz doppler extractor port 8 (Fig. 1). The X-band uplink and X-band downlink frequencies for this test were 7177.92 MHz and 8433.33 MHz, respectively. The subsystems included in the test configuration are the exciter subsystem, X-band transmitter (in closed-loop mode), X-band UL to X-band DL frequency translator, X-band maser, X-band MMR, 36.6 m of 315-MHz IF cable, X-band system upconverter/downconverter, Block III closed loop receiver, and 1-MHz doppler extractor. In addition, XTIME and YFREQ plots are shown in Fig. 9. These plots are useful for studies of how the stability varied with time during the testing. As discussed in [1], the EECLX results may not be valid due to suspected leakage signals in the closed-loop configuration. These leakage signals were discovered after testing was completed. They cannot be eliminated without major redesign of the receiving system. The results are presented here for reference and future comparison purposes only.

Figure 10 is an Allan sigma plot for end-to-end system tests made on the EEOLX configuration, where the output test port is the phase detector (mixer) output port 11 (Fig. 1). The X-band uplink and X-band downlink frequencies for this test were 7166.94 MHz and 8420.43 MHz, respectively. The subsystems included in the test configuration are the exciter subsystem, X-band transmitter (in closed-loop mode), X-band UL to X-band DL frequency translator, X-band maser, X-band MMR, 36.6 m of IF cable, X-band system upconverter/downconverter, and Block III receiver operating in a modified open-loop configuration.

Figure 10 also shows XTIME and YFREQ plots, which are useful for studies of how the stability varied with time during the testing. The test results are excellent and indicate that end-to-end system stabilities of better than  $2.0 \times 10^{-15}$  can be achieved for  $\tau = 1000$  s. It should be pointed out, as was pointed out in [1], that the results do not include the stability of the H-maser frequency source, and do not include antenna effects above the transmitter coupler output port. For this test result, as for all results in this article, the antenna was stationary at the zenith position.

Figure 11 is an Allan sigma plot for the XLTRS test configuration where the output test port is port 12 (Fig. 2). The X-band uplink and S-band downlink frequencies for this test were 7162.3 MHz and 2295 MHz, respectively. Normally included in this test configuration are the exciter subsystem,

X-band transmitter, and the X-band UL to S-band DL frequency translator. However, the X-band transmitter was not included in this configuration due to a desire to not overuse the X-band transmitter unnecessarily for some types of subsystem testing.

Figure 12 is an Allan sigma plot for the MMRS test configuration where the output test port is port 13 (Fig. 2). The X-band uplink and S-band downlink frequencies for this test were 7162.3 MHz and 2295 MHz, respectively. The subsystems normally included in the test configuration are the exciter subsystem, X-band transmitter, X-band UL to S-band DL frequency translator, S-band maser, S-band MMR, and 36.6 m (1,200 ft) of cable carrying the 295-MHz IF signal back to the control room. The X-band transmitter was not included in the particular tests performed on this configuration.

Figure 13 gives Allan sigma, XTIME, and YFREQ frequency stability plotted results for the EECLS test configuration, where the output test port is the 1-MHz doppler extractor port 14 (Fig. 2). The X-band uplink and S-band downlink frequencies for this test were 7180.0 MHz and 2300.7 MHz, respectively. The subsystems included in the test configuration are the exciter subsystem, X-band transmitter (in closed-loop mode), X-band UL to S-band DL frequency translator, S-band maser, S-band MMR, 36.6 m of 295-MHz IF cable, S-band system upconverter/downconverter, Block III closed-loop receiver, and 1-MHz doppler extractor. As discussed in [1], the EECLS results might not be valid due to suspected leakage signals in the closed-loop configuration. The results are presented here for reference and future comparison purposes only.

Figure 14 gives Allan sigma, XTIME, and YFREQ frequency stability plotted results for EEOLS test configuration where the output test port is the 10-MHz port 16 (Fig. 2). The results at this test port were obtained by mixing the 10 MHz output signal with 10 MHz plus 1 Hz signal from an HP8662A synthesizer that was driven by a reference frequency from the H-maser frequency distribution system. It would have been simpler to test this EEOLS configuration at port 17 (Fig. 2) rather than at port 16. The X-band uplink and S-band downlink frequencies for this test were 7162.3 MHz and 2295 MHz, respectively. The subsystems included in the test configuration are the exciter, X-band transmitter (in closed-loop mode), X-band UL to S-band DL frequency translator, S-band maser, S-band MMR, 36.6 m of 295-MHz IF cable, S-band system up converter/down converter, and Block III receiver operating in a modified open-loop configuration. The results for this test configuration were not as good as expected, but are inconclusive. It is not known whether the S-band maser or the Block III receiver synthesizer was operating properly at the time. Further testing was not performed on this configu-

ration at the time because the interest was primarily in obtaining test data for the X-band downlink configurations. More tests for this configuration need to be made in the future.

### III. Concluding Remarks

The conclusions applicable for this article are the same as those given in the previous report [1]. The purpose of this article was to present Allan sigma plots for each of the test configurations whose results were reported previously. The results presented were intentionally selected to be the best of each test configuration. With the exception of the XLTRX, MMRX, XLTRS, and MMRS test configurations, the plots presented were also typical of the results obtained most frequently during the test period from March 1985 through July 1986 at DSS 13 as well as previous test periods, where results were reported on internal JPL reports.

In addition to concluding remarks given in the previous article [1], it can be further stated that Allan sigma plots are useful and necessary for the evaluation of the performance of

station stability. Obtaining a  $\sigma$  value only at  $\tau = 1000$  s can sometimes lead to an erroneous conclusion that the system is performing well or badly.

It is recommended that as standard procedure, the total data set be saved on tape or diskette so that it can be post-processed for Allan sigma, XTIME, and YFREQ plots with the aid of a computer program similar to that developed by Greenhall. The XTIME and YFREQ plots are useful for study of the time history of station stability during the test period and also for diagnostic purposes. It is also recommended that for station stability tests, a log book be kept of unusual station events. If the bad data points can be correlated to non-typical unusual station events, the test data can be salvaged and edited. For this article, editing was done on the data set for two test configurations as noted in the tables. For the tests performed at DSS 13, the tests were performed with instrumentation [1] that provided real-time visual and audio indications whenever bad data points occurred during the test. This type of real-time bad-data-point warning system proved to be invaluable for station stability testing.

### References

- [1] T. Y. Otoshi, and M. M. Franco, "DSS 13 Frequency Stability Tests Performed During May 1985 through March 1986," *TDA Progress Report 42-86*, Vol. April-June 1986, pp. 1-14, Jet Propulsion Laboratory, Pasadena, Calif., August 15, 1986.
- [2] C. G. Greenhall, "Frequency Stability Review," *TDA Progress Report 42-88*, Vol. October-December 1986, pp. 200-212, Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1987.
- [3] A. L. Berman, "The Gravitational Wave Detection Experiment: Description and Anticipated Requirements," *TDA Progress Report 42-46*, Vol. April-June 1986, pp. 100-108, Jet Propulsion Laboratory, Pasadena, Calif., August 15, 1978.

**Table 1. Summary of FFS values for  $\tau = 1000$  s only<sup>a</sup> for X-band uplink frequency**

Test ID	Test Period	Test Port <sup>b</sup>	Test Description	FFS for $\tau = 1000$ s	Comments
EXCCL	Feb. 86	4	Exc closed loop, 7166.94 MHz UL (Galileo Ch 18), two-mixer method, 4096 data pts.	2.51E-16 3 #SDP Test freq = 7166.94 MHz	Used two-mixer method. See Fig. 3 for corresponding Sigma vs Tau plot.
EXCCL	Feb. 86	4	Exc closed loop, 7200 MHz UL, one-mixer method, 11,008 data pts.	7.65E-16 10 #SDP Test freq = 7200 MHz	Used one-mixer method. See Fig. 4 for corresponding Sigma vs Tau plot.
XMTCL	May 85	5	X-band xmtr closed loop, 15 kW saturated, 7200 MHz UL, 4791 data pts.	1.76E-15 3 #SDP Test freq = 7200 MHz	Edited data set. Used only pts 1-4791 of the original data set. See Fig. 5 for corresponding Sigma vs Tau plot.
XMTOL	May 85	5	X-band xmtr open loop, 7200 MHz UL, 14,432 data pts.	1.42E-15 13 #SDP Test freq = 7200 MHz	Good result for open loop xmtr test. See Fig. 6 for corresponding Sigma vs Tau plot.

<sup>a</sup>Test results for other  $\tau$  values are shown in Figs. 3-6.

<sup>b</sup>See Fig. 1 block diagram for this output signal test port location in the X-band uplink system.

**Table 2. Summary of FFS values for  $\tau = 1000$  s only<sup>a</sup> for X-band uplink and X-band downlink frequency**

Test ID	Test Period	Test Port <sup>b</sup>	Test Description	FFS for $\tau = 1000$ s	Comments
XLTRX	Dec. 85	6	Exciter, X-band xmtr bypassed, X-band xltr, 7162.3 MHz UL, 8415.0 MHz DL, two-mixer method, +3 dBm into second mixer, 14,368 data pts.	1.56E-15 13 #SDP Test freq = 8415 MHz	Note that xmtr not included. Used two-mixer method to get 8415 MHz test signal. Results are as good as 8400 MHz results reported elsewhere. See Fig. 7 for corresponding Sigma vs Tau plot.
MMRX	July 86	7	Exciter, X-band xmtr bypassed, X-band xltr, X-band maser, X-band MMR, 7162.31 MHz UL, 8415.00 MHz DL, 315 MHz IF in control room, 17,024 data pts.	2.90E-16 16 #SDP Test freq = 8415 MHz	Note that xmtr not included. Results better than expected. See Fig. 8 for corresponding Sigma vs Tau plot.
EECLX	Jan. 86	8	End-to-end test with xmtr (15 kW), 7177.92 MHz UL, 8433.33 MHz DL, 1 MHz doppler extractor port, 14,432 data pts.	5.93E-16 13 #SDP Test freq = 8433.33 MHz	This good result might not be valid due to leakage signals in closed loop rcvr. See Fig. 9 for the corresponding Sigma vs Tau plot.
EEOLX	Mar. 86	11	End-to-end test with 15 kW xmtr, 7166.94 MHz UL, 8420.43 MHz DL, modified open loop rcvr output port, 12,032 data pts.	9.51E-16 11 #SDP Test freq = 8420.43 MHz	Better than expected end-to-end system result. See Fig. 10 for corresponding Sigma vs Tau plot.

<sup>a</sup>Test results for other  $\tau$  values are shown in Figs. 7-10.

<sup>b</sup>See Fig. 1 for this output signal test port location in the X-band uplink and X-band downlink system.

**Table 3. Summary of FFS values for  $\tau = 1000$  s only<sup>a</sup> for X-band uplink and S-band downlink frequency**

Test ID	Test Period	Test Port <sup>b</sup>	Test Description	FFS for $\tau = 1000$ s	Comments
XLTRS	July 85	12	Exciter, X-band xmtr bypassed, S-band xltr, 7162.3 MHz UL, 2295.0 MHz DL, two-mixer method, 14,368 data pts.	2.05E-15 13 #SDP Test freq = 2295 MHz	Note that xmtr not included. Results are reasonable for S-band DL. See Fig. 11 for corresponding Sigma vs Tau plot.
MMRS	July 85	13	Exciter, X-band xmtr bypassed, S-band xltr, S-band maser, MMR, 7162.3 MHz UL, 2295.0 MHz DL, 295 MHz IF in control room, 8000 data pts.	1.02E-15 6 #SDP Test freq = 2295 MHz	Xmtr not included. Edited data set. Used pts 8201-16200 only of original data set. See Fig. 12 for corresponding Sigma vs Tau plot.
EECLS	Nov. 85	14	End-to-end system without xmtr, 7180.0 MHz UL, 2300.7 MHz DL, rcvr closed loop, 1 MHz doppler extractor output, 15,104 data pts.	4.60E-15 14 #SDP Test freq = 2300.7 MHz	These good results might not be valid due to suspected leakage signals in the closed loop rcvr system. See Fig. 13 for corresponding Sigma vs Tau plot.
EEOLS	Nov. 85	16	End-to-end system without xmtr, 7162.3 MHz UL, 2295.0 MHz DL, rcvr in modified open loop, 10 MHz output port, 9472 data pts.	1.52 E-14 8 #SDP Test freq = 2295 MHz	Results not as good as expected for S-band DL freq. See Fig. 14 for corresponding Sigma vs Tau plot.

<sup>a</sup>Test results for other  $\tau$  values are shown in Figs. 11-14.

<sup>b</sup>See Fig. 2 for this output signal test port location in the X-band uplink and S-band downlink system.





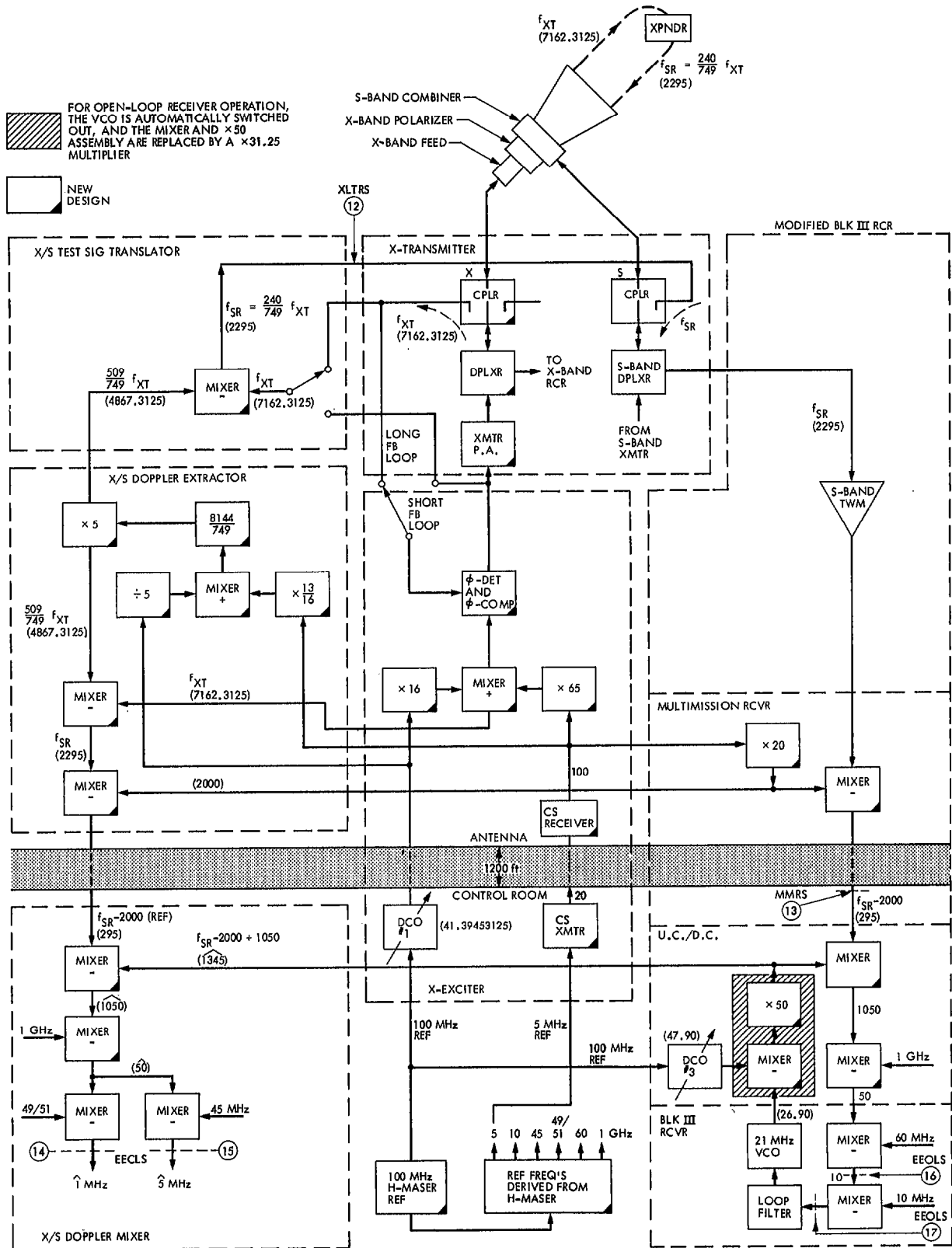


Fig. 2. Output test ports for frequency stability testing on X-band uplink and S-band downlink subsystems at DSS 13 (same as Fig. 2 of [1]). Example frequencies are for channel 14.

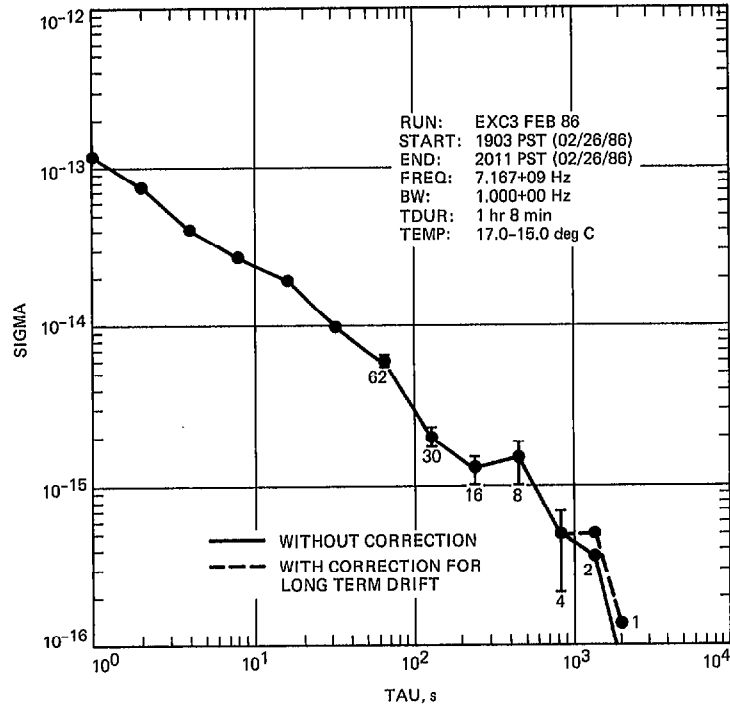


Fig. 3. Allan sigma plot for an exciter output test at port 4 (see Fig. 1) using a two-mixer method

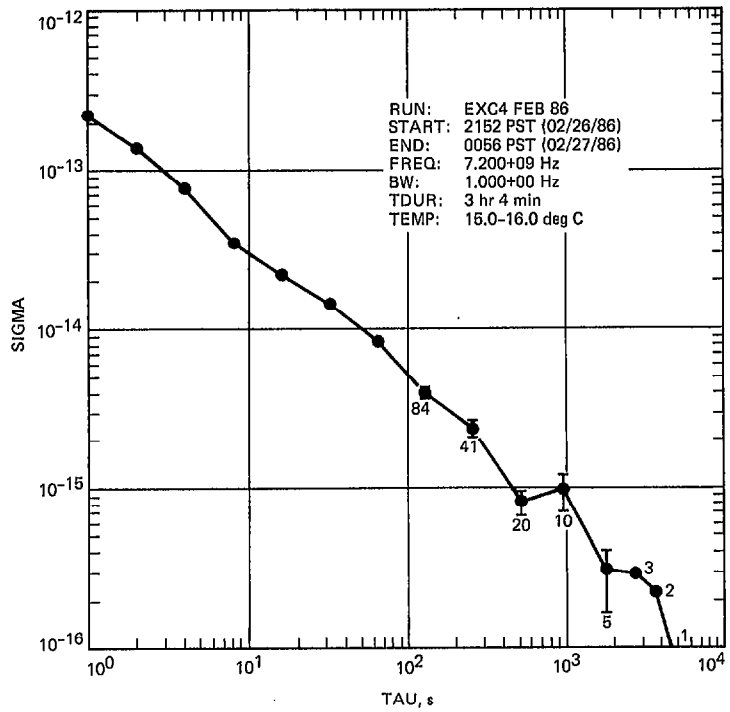
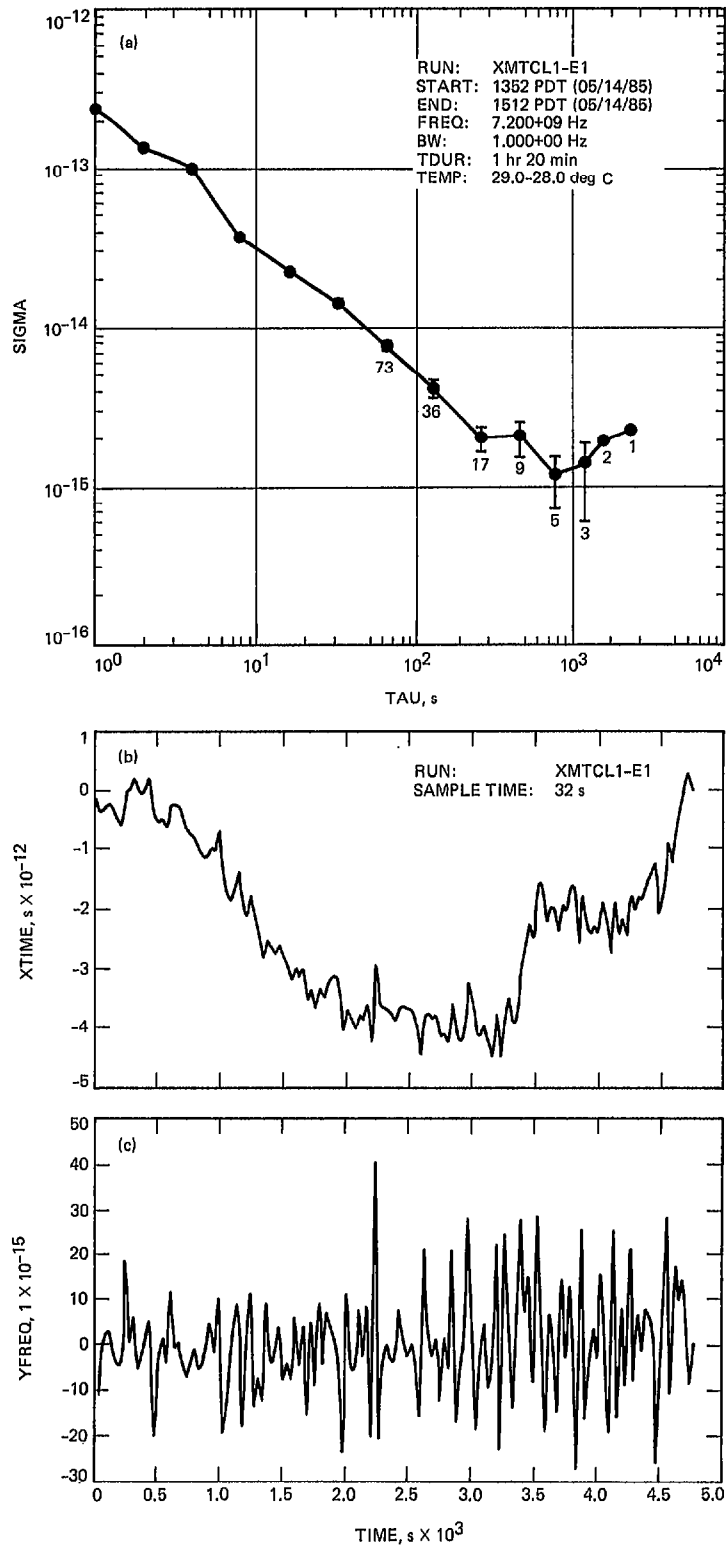
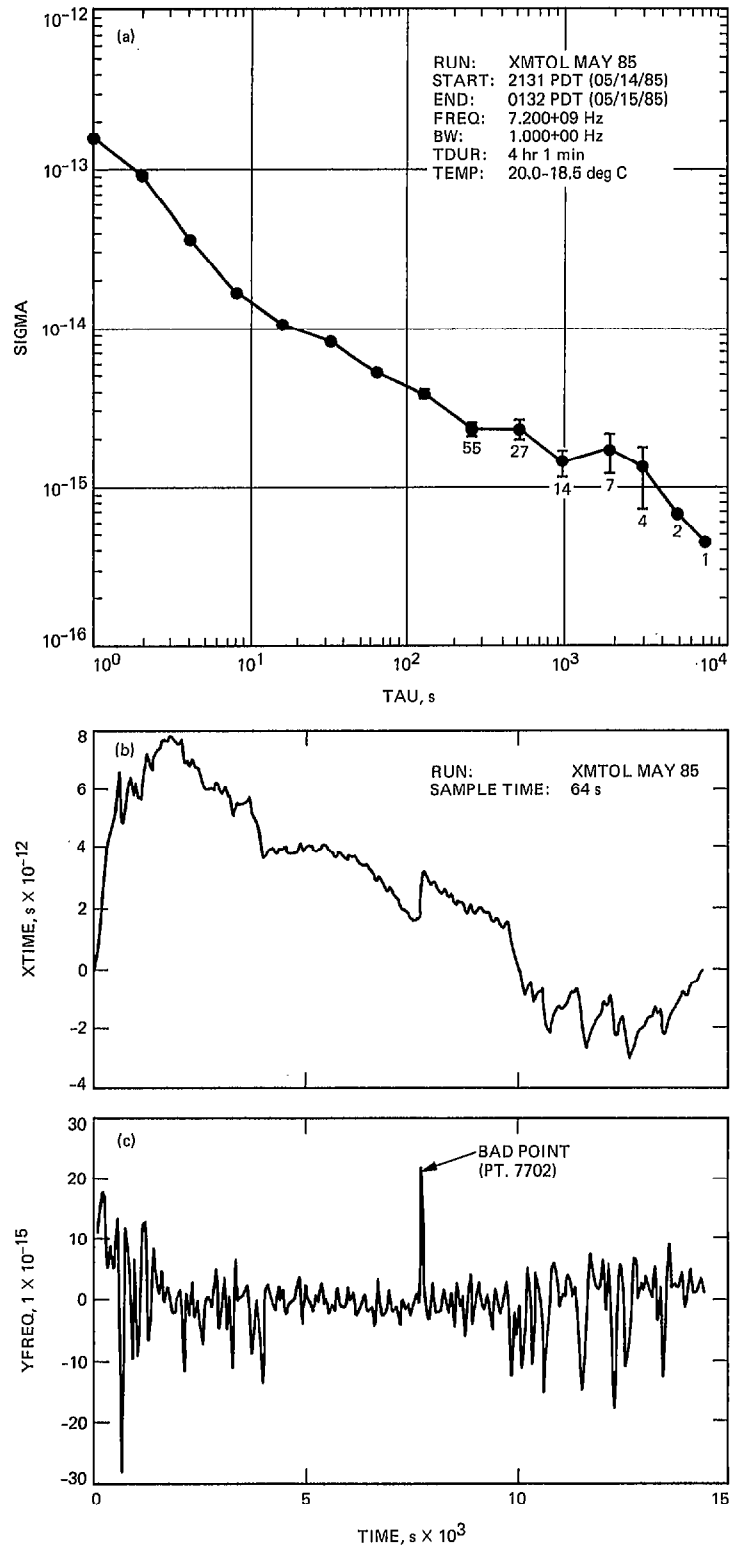


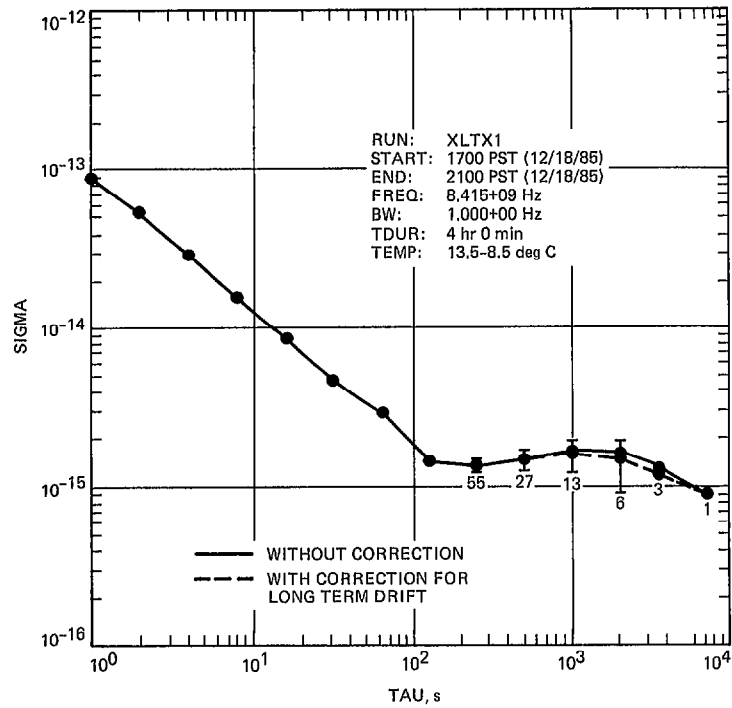
Fig. 4. Allan sigma plot for an exciter output test at port 4 (see Fig. 1) using a single mixer method



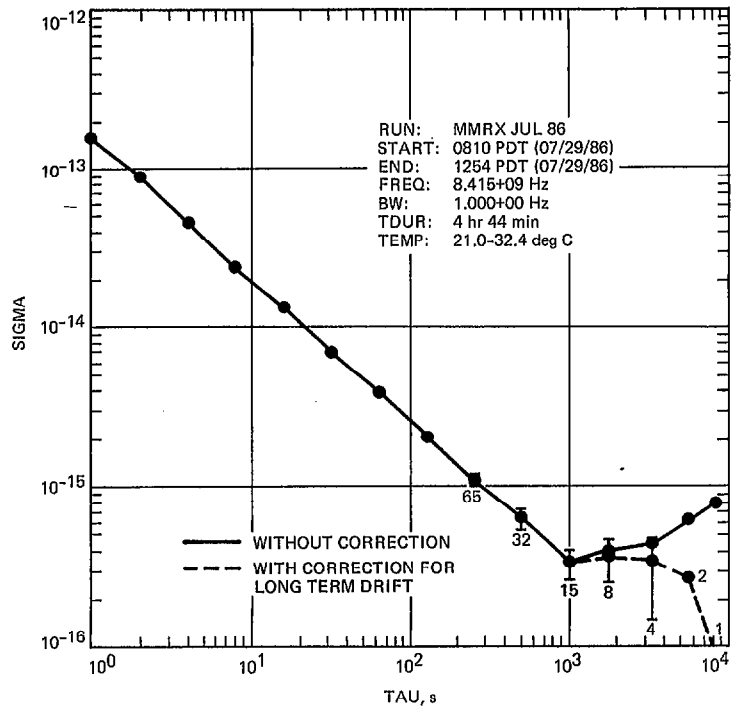
**Fig. 5. Frequency stability plots for an X-band transmitter closed loop output test at port 5 (see Fig. 1): (a) Allan sigma, (b) XTIME, and (c) YFREQ**



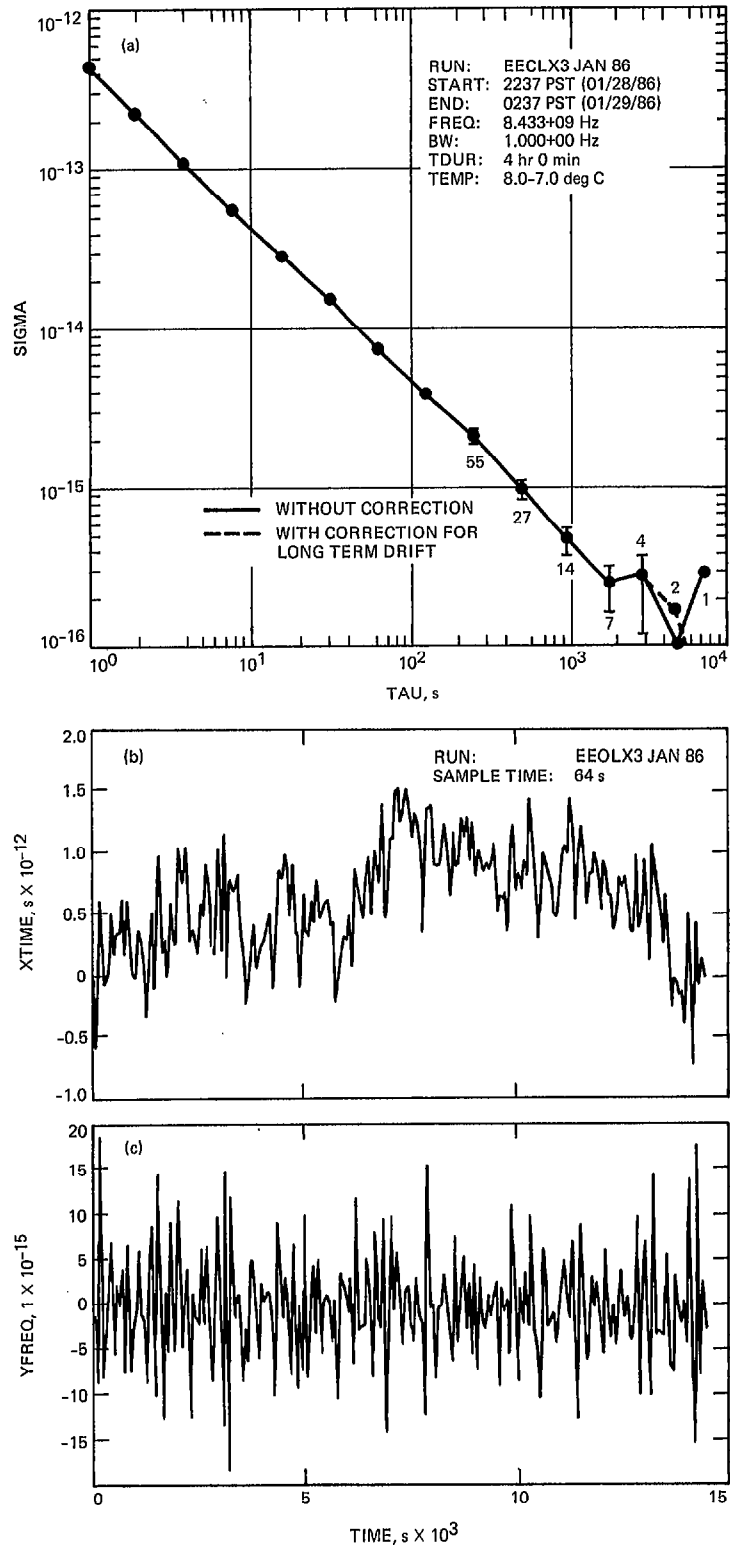
**Fig. 6. Frequency stability plots for an X-band transmitter open loop output test at port 5 (see Fig. 1): (a) Allan sigma, (b) XTIME, and (c) YFREQ**



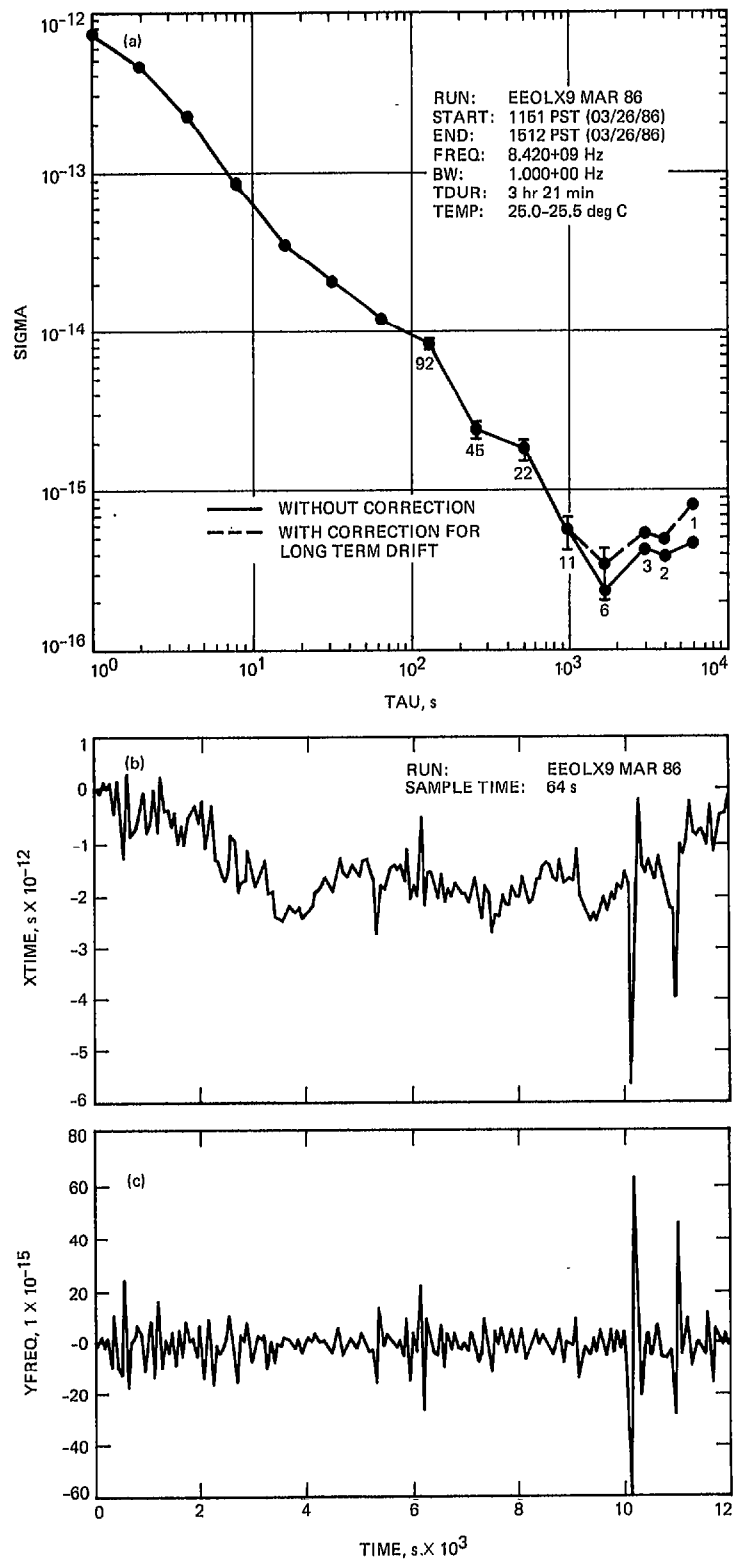
**Fig. 7. Allan sigma plot for an X-band translator output test at port 6 (see Fig. 1). The X-band transmitter was not included in the test configuration for this particular test result.**



**Fig. 8. Allan sigma plot for an X-band Multi-Mission Receiver (MMR) output test at port 7 (see Fig. 1). The X-band transmitter is not included in the test configuration for this particular test result.**



**Fig. 9. Frequency stability plots for an end-to-end X-band uplink and X-band downlink system test with the receiver in closed loop configuration: (a) Allan sigma, (b) XTIME, and (c) YFREQ. The output port is the 1 MHz doppler extractor port 8 shown in Fig. 1.**



**Fig. 10. Frequency stability plots for an end-to-end X-band uplink and X-band downlink system test with the receiver in a modified open loop configuration: (a) Allan sigma, (b) XTIME, and (c) YFREQ. The output port is the phase detector (mixer) output port 11 shown in Fig. 1.**

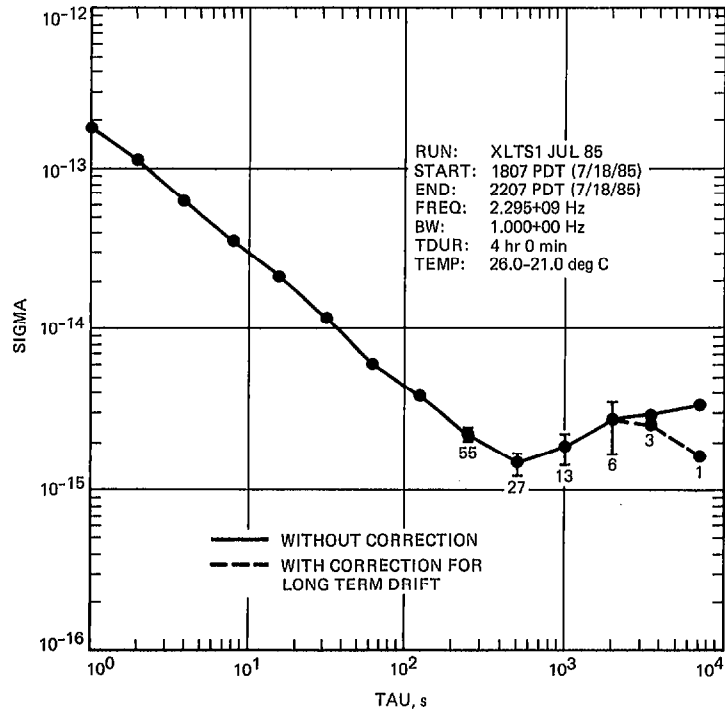


Fig. 11. Allan sigma plot for an S-band translator output test at port 12 (see Fig. 2). The X-band transmitter is not included in the test configuration.

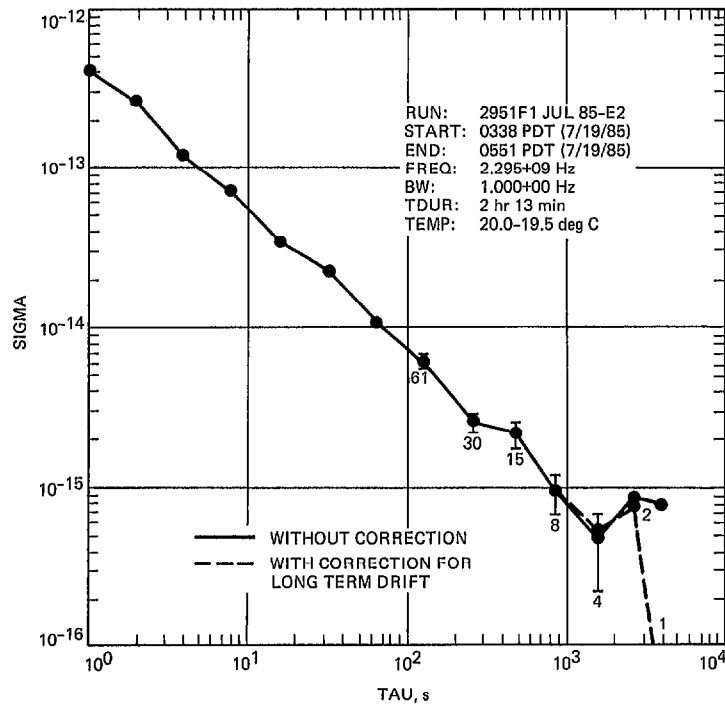
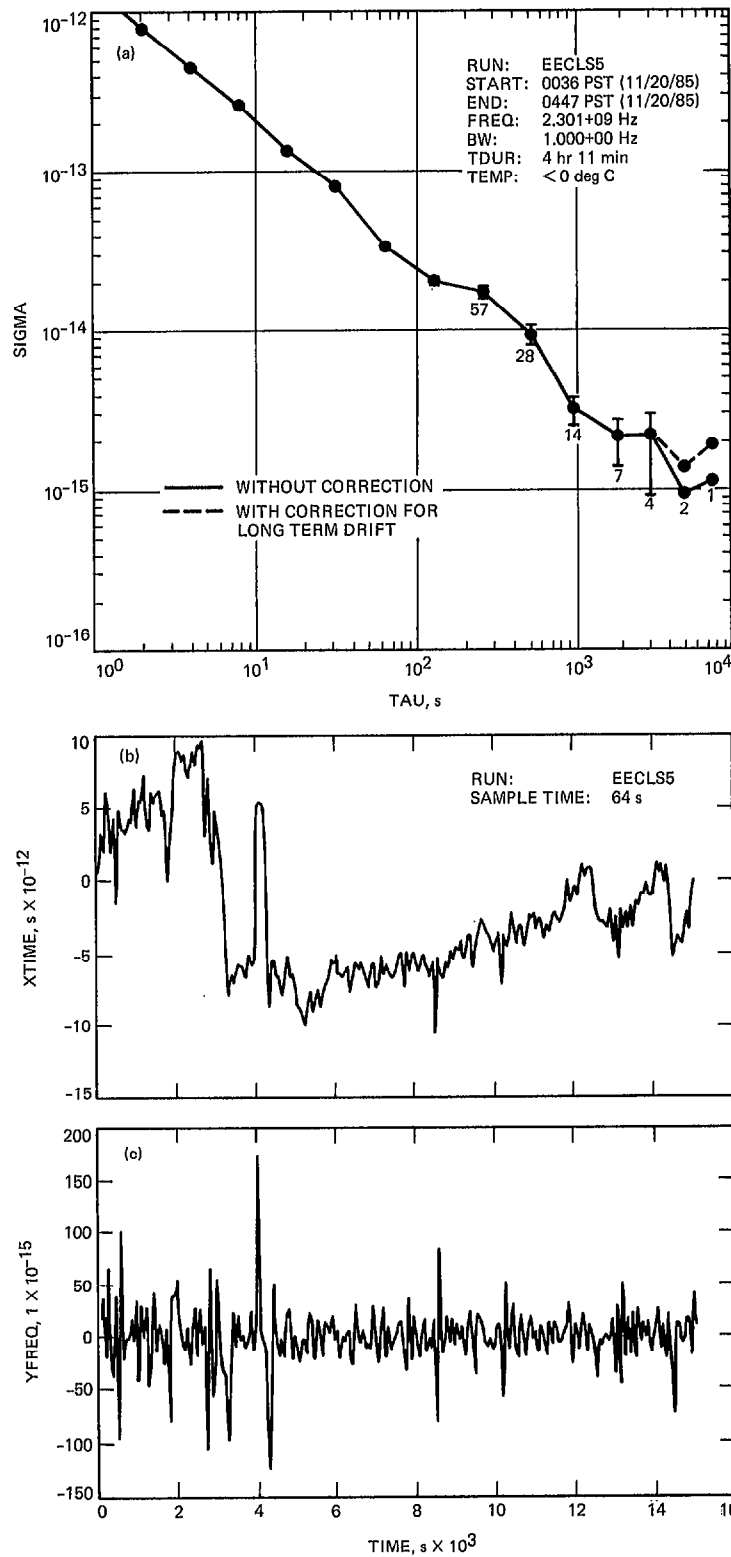


Fig. 12. Allan sigma plot for an S-band Multi-Mission Receiver (MMR) output test at port 13 (see Fig. 2).





**Fig. 13. Frequency stability plots for an end-to-end X-band uplink and S-band downlink system test with the receiver in closed loop configuration: (a) Allan sigma, (b) XTIME, and (c) YFREQ. The output port is the 1 MHz doppler extractor port 14 shown in Fig. 2.**

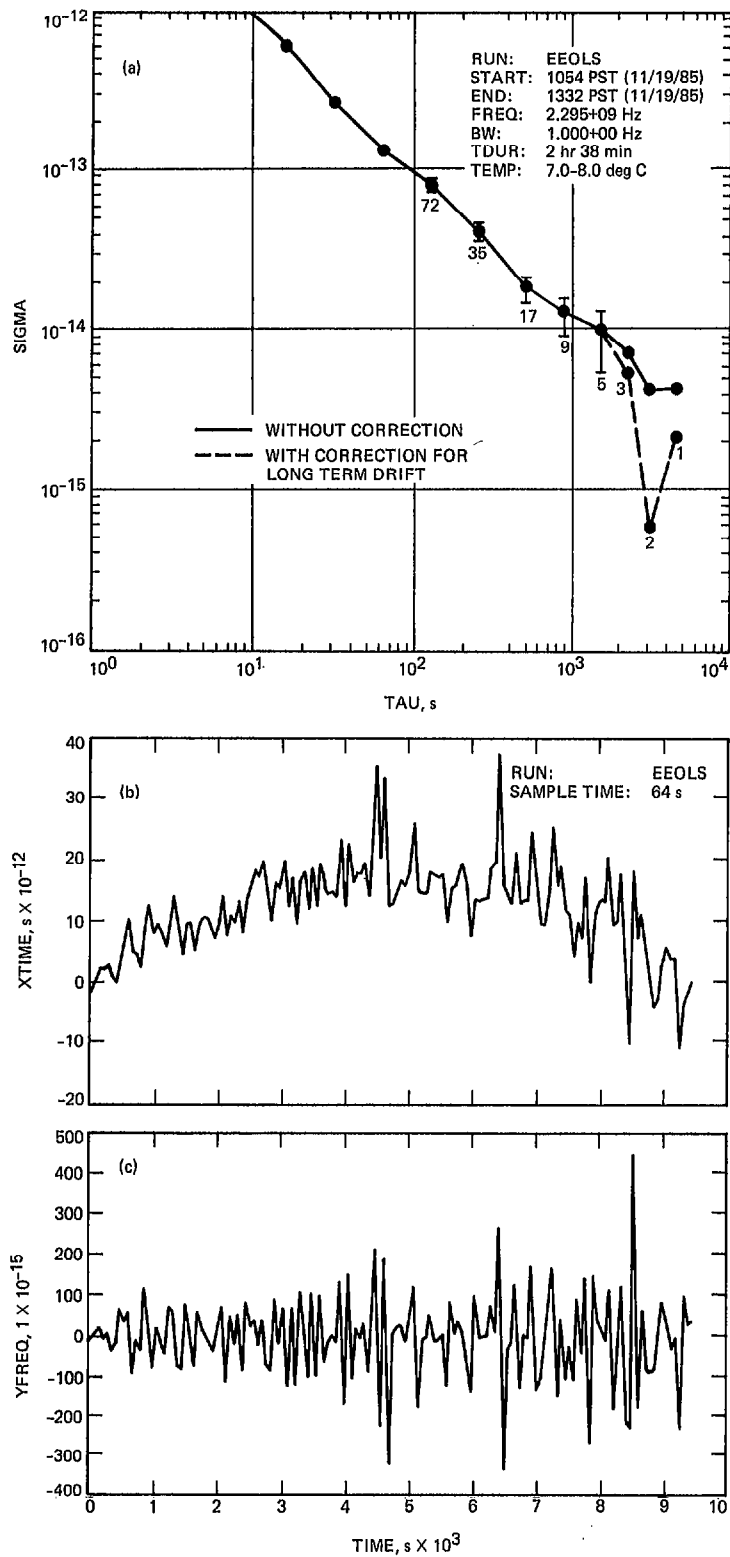


Fig. 14. Frequency stability plots for an end-to-end X-band uplink and S-band downlink system test with the receiver in a modified open loop configuration: (a) Allan sigma, (b) XTIME, and (c) YFREQ. The output port is the 10 MHz output port 16 shown in Fig. 2.

## Appendix A

### Nomenclature

Symbols that are used for description of test configurations are defined as follows:

<b>EXCCL</b>	Exciter output test configuration or chain for the exciter operating closed loop. The subsystems included in this configuration (or chain) are the transmitter synthesizer, X 16 multiplier, 36.6 m (1,200 ft) of uncompensated cable running from the synthesizer in the control room to the exciter subsystem in the cone, cable stabilized 100 MHz subsystem, and the exciter subsystem itself.	<b>EECLX</b>	End-to-end system test configuration for X-band UL and X-band DL chain that includes the MMRX chain and Block III receiver #1 and doppler extractor subsystems. Block III receiver #1 is operating in a closed-loop mode.
<b>XMTCL</b>	Transmitter output test configuration or chain when the X-band transmitter is operating closed loop. The subsystems included in this configuration consist of the buffer amplifier, klystron, feedback loop, and exciter chain described previously except with the exciter operating in open-loop mode.	<b>EECLS</b>	End-to-end system test configuration for X-band UL and S-band DL chain that includes the MMRS chain and Block III receiver #2 and doppler extractor subsystem. Block III receiver #2 is operating in a closed-loop mode.
<b>XMTOL</b>	Transmitter output test configuration when the X-band transmitter is operating open loop. The subsystems included in this configuration are the same as for the XMTCL configuration except that the exciter can be operating in either the closed-loop or open-loop mode. For all tests for this configuration, the exciter was intentionally operated in the closed-loop mode.	<b>EEOLX</b>	End-to-end system test configuration for X-band UL and X-band DL chain that includes the MMRX chain and parts of the Block III receiver #1 subsystem. Block III receiver #1 is operating in a modified open-loop mode.
<b>XLTRX</b>	Translator X-band output test configuration for an X-band UL and X-band DL chain that consists of either the exciter or transmitter chain and the X-band UL to X-band DL frequency translator subsystem.	<b>EEOLS</b>	End-to-end system test configuration for X-band UL and S-band DL chain that includes the MMRS chain and parts of the Block III receiver #2 subsystem. Block III receiver #2 is operating in a modified open-loop mode.
<b>XLTRS</b>	Translator S-band output test configuration for the X-band UL and S-band DL chain that consists of the exciter or transmitter chain and the X-band UL and S-band DL frequency translator.	Other abbreviations appearing in tables or figures are presented in alphabetical order and are defined as follows:	
<b>MMRX</b>	X-band Multi-Mission Receiver output test configuration for the X-band UL and X-band DL chain that now consists of either the transmitter or exciter chain, X-band UL to X-band DL frequency translator subsystem, X-band maser, and an R&D version X-band MMR receiver.	<b>BW</b>	Bandwidth
<b>MMRS</b>	S-band Multi-Mission Receiver output test configuration for the X-band UL and S-band DL chain that now consists of either the transmitter or exciter chain, X-band UL to S-band DL frequency translator subsystem, S-band maser, and an R&D version S-band MMR receiver.	<b>CS</b>	Cable Stabilizer
		<b>DL</b>	Downlink
		<b>EXC</b>	Exciter
		<b>FFS</b>	Fractional Frequency Stability or the Allan sigma (square root of the Allan variance of deviations, of observed frequencies from the test frequency, divided by the test frequency)
		<b>Freq</b>	Frequency
		<b>#SDP</b>	Number of second difference points used to compute the FFS
		<b>PDT</b>	Pacific Daylight (Savings) Time
		<b>PST</b>	Pacific Standard Time
		<b>Pts</b>	Points
		<b>Rcvr</b>	Receiver
		<b>Run</b>	Test run or test data identification
		<b>Temp</b>	Outside air temperature as measured at the cable bulkhead interface of the DSS 13 control room

Tdur	Test duration				surements. It is calculated for a specified sampling time interval. It is plotted as a function of time relative to start of test time. See [2] for more details.
UL	Uplink				
Xltr	Translator				
Xmtr	Transmitter				
XTIME	Deviation of observed clock time from true clock time as determined from frequency stability mea-				
		YFREQ			Average normalized frequency deviation for a specified sampling time interval. It is plotted as function of time relative to start of test time. See [2] for more details.